DESIGN OF 2 T WIGGLER VACUUM CHAMBER FOR THE LNLS STORAGE RING

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Abstract

A 2 T wiggler with 2.8 m length and a gap of 22 mm will be installed at the LNLS storage ring. The main requirements of the vacuum chamber design are short conditioning time and low mechanical deformation. Two different designs in stainless steel are proposed for the prototypes, an elliptical tube and a machined sheet. The average pressure profile simulation with and without a non-evaporable getter (NEG) coating was made for evaluating the life-time influence. A finite element analysis of mechanical deformation for both cases shows equivalent results. The first prototype was made with the elliptical tube and a NEG coating deposition will be made at the ESRF. The second prototype with machined parts is under construction and will be TIG welded. Descriptions of the prototypes and the evaluation of the dimensional tolerance of the chambers are shown.

INTRODUCTION

All beamlines at LNLS synchrotron light source use radiation from a bending magnet (1.67 T with critical photon energy at 2.084keV). The new insertion device, a multipolar wiggler source [1], will provide a high flux photon beam for the Protein Crystallography. The first wiggler beamline is under construction and optimized for the Multiple Wavelength Anomalous Dispersion (MAD) technique at 12.4keV. The technical specification for the vacuum chamber is detailed in table 1.

The magnet gap specification is a compromise between the conflicting requirements of largest possible peak field (which demands small gaps) and good injection efficiency an beam lifetime, which favours larger gaps [2]. The material choice was the stainless steel (SS) 304 and 316LN, due to their high mechanical stress and low magnetic permeability (<1,005) properties.

Table 1: Specification for the vacuum chamber

Magnet gap	22,0 mm
Maximum external chamber height	21,0 mm
Vertical beam stay clear	19,0 mm
Horizontal beam stay clear	60,0 mm
Average pressure with beam (400 mA at 1.37 GeV)	$2x10^{-9}$ mbar

CHAMBER DESIGN

The main vacuum difficulties are the small dimensions, the great aspect ratio with cross section and the length of the insertion device chamber and the mechanical quality of the maximum vertical external and internal dimension.

An average pressure of 5 x 10^{-9} Torr is necessary for a lifetime of 10 hours. The vacuum simulations of the tube were done with the Monte Carlo program CHEVRO4 [3]. An elliptical cross section with half dimension radius of 3.5 cm and 0.95 cm and 300 cm length results in a conductance of 2.1 l/s. The low conductance of the ID vacuum chamber increases the average pressure. The simulation of the average pressure distribution was performed with the program PRESSURE5 [4] at 400mA of current in the insertion device sector with the following configuration:

1. standard straight section, with an ion pump (20l/s) in the middle of the sector after 100Ah (average pressure 2.2 x 10^{-9} Torr),

2. wiggler chamber in the same sector with two ion pumps at their ends with 260 l/s and 40 l/s, after 100Ah (average pressure 2.1 x 10^{-9} Torr),

3. wiggler chamber with NEG coating in the same sector after 30Ah (average pressure 1.89 x 10^{-9} Torr),

The results for items 1 and 2 are very similar and it means a lower life-time during some months to accumulate the 100Ah of integrated dose. Item 3 shows how short the conditioning time with the NEG coating could be [5].

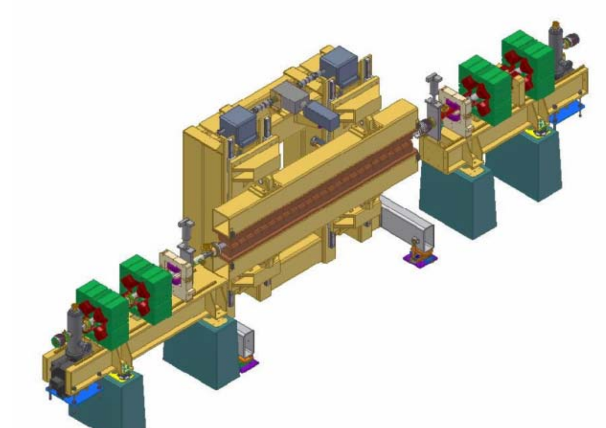

Figure 1. Insertion device sector with wiggler.

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A tolerance of ±0.2 mm in vertical direction with an alignment error and safety conditions requested for an insertion not to touch the chamber in a critical fail (minimum gap of 21.7 mm with hardstops) is very restrictive. Some simulations with ANSYS7.0 were performed to calculate the maximal deformation of the chambers under vacuum conditions to optimize the geometry of the support.

The mechanical aspects of production suggest two solutions. A 304 SS elliptical tube with dimensions of 21.0 x 73.6 mm (figure 2) and a 316LN quasi-elliptical 21.0 x 73.0 mm machined (figure 3).

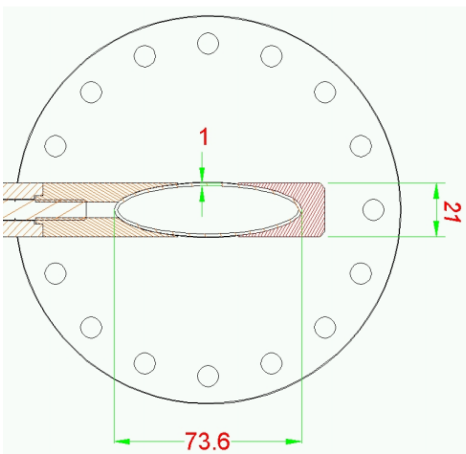

Figure 2. A 304 SS tube with both sides supported and the CF 100 flange

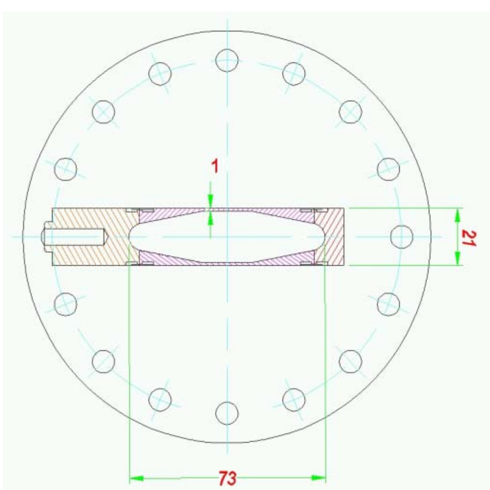

Figure 3. A machined 316LN SS TIG welded and the CF 100 flange

The simulation of the tube under vacuum conditions with one side continuous support shows an unacceptable plastic deformation of 0.144 mm. The solution was to add a second support along the profile in the external side, which gives a deformation of 0.032 mm (figure 4).

The simulation of the machined version starts with the elliptical profile with a deformation of 0.05 mm. The difficulty to produce such a profile suggested an approximately elliptical profile composed of straight parts. That results in a deformation of 0.04 mm (figure 5).

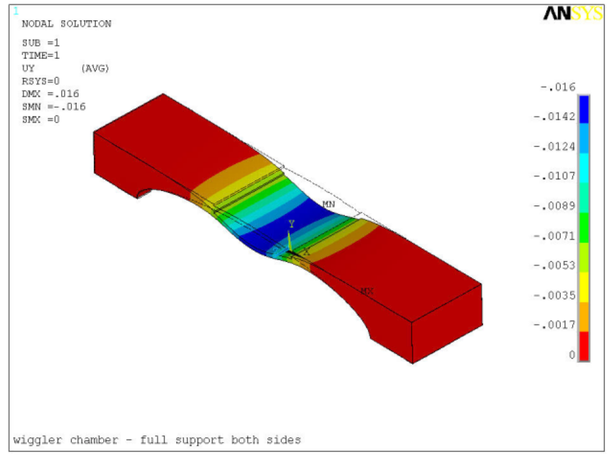

Figure 4. Deformation of the elliptical tube with two side support.

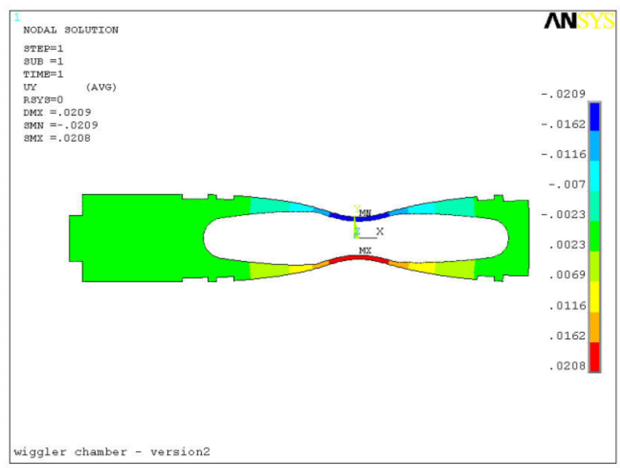

Figure 5. Deformation of a quasi-elliptical cross section

PROTOTYPE CONSTRUCTION

The prototype 304 SS tube received a thermal treatment (1120ºC, 1 hour) to assure the magnetic permeability <1,005 after the mechanical conformation. All the supports were made of 316LN SS. The main difficulty was to adjust the tube with the continuous support for welding at one side and the other side with 2 mm thickness ribs with a distance of 40 mm (figure 6). The measured average deformation of the chamber under vacuum was 0.08, and the simulation has a good agreement of 0.06mm (figure 7). The maximum vertical height measured without vacuum was 21.58 mm, the minimum 20.85 mm. Under vacuum conditions the height measured are respectively 21.40 mm and 20.74mm. This prototype was sent to the ESRF Vacuum Group for NEG deposition in their facility [5] as part of cooperation between ESRF and LNLS. This NEG deposition will be used for the evaluation of the coating characteristic at the LNLS Vacuum Group.

Three prototypes were produced with a short length (30 cm) to check the procedures of the machining of production, welding and deformation after welding. The flatness of the chamber with the support for welding was inside the range of ±0.31 mm and after the welding ±0.15 mm.

Figure 6. Spot welding the 304 SS tube with the continuous support and ribs.

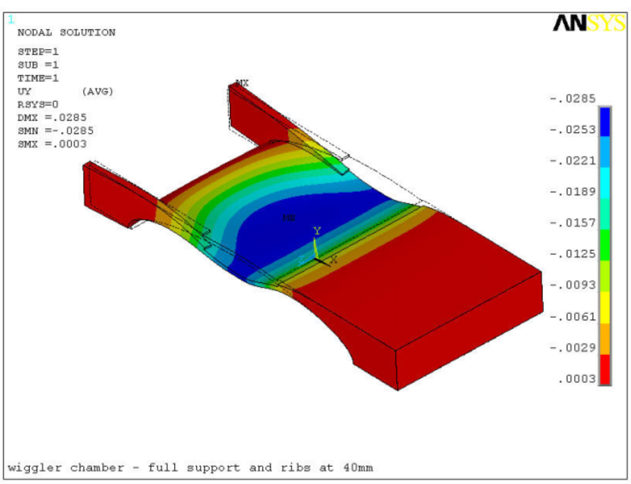

Figure 7. Maximum deformation of 0.06 mm with the continuous support and 2 mm thickness ribs

The pieces of two prototypes, one for each version, are under construction by companies with some modification added after the preliminary test. The final choice of model to be adopted will include a magnetic measurement of the prototypes, a final pressure procedure including a residual gas analyses and the measurement of the mechanical deformation under vacuum.

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